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ABSTRACT

This report focuses on the status and future of computer technology in Massachusetts schools. The report is organized into four major sections. Introductory information is provided in section 1, followed by a framework (section 2) for viewing computer technology. This framework provides information on computer hardware components, computer software and software-related terminology, and applications which are anticipated for the computer. An attempt is made to help decision-makers set directions for computer use in the future by summarizing (section 3) seven projects illustrating the types of instructional/administrative applications for which computer technology is helpful. Projects summarized include: Project CAPTURE, Project LOGIC, Education Programs and Practices File, A Network of Practice File, Computer-Assisted Instruction, Project COFFEE, Lawrence Children's Health Project/EPSDT, and the Computer Literacy Institute. Lessons learned from these projects that should be of assistance to those contemplating future development of computer technology in education are discussed in section 4. These lessons address various issues related to staff development, curriculum/instruction, and technical assistance. A glossary of microcomputer terms and names/addresses of project contact persons are included in appendices. Additional descriptive and curriculum documents are available from these individuals. (JN)

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COMPUTER TECHNOLOGY IN MASSACHUSETTS SCHOOLS

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SEPTEMBER, 1932

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COMPUTER TECHNOLOGY IN MASSACHUSETTS SCHOOLS

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FOREWORD

Some exciting applications for computer technology have been developed by Massachusetts school districts over the past few years. This use of technology is expected to continue to grow in the coming years--partly due to increased pressures to bring schools into the technology age and partly due to the increased availability of quality educational software.

In an effort to summarize some of the projects in Massachusetts that have used computers and, with the intention of drawing lessons from those experiences, the Merrimack Education Center has prepared this report entitled "Computer Technology in Massachusetts Schools", as part of a Title IV-C grant.

This report presents a framework for viewing computer technology. A brief review of software and hardware terminology is offered along with a discussion of the types of instructional and administrative applications for which computer technology is helpful. The report goes on to summarize seven projects, four of which use Title IV-C funds, as examples of these applications including:

- Project CAPTURE, Uxbridge
- Project LOGIC, Hampshire Educational Collaborative
- A Network of Practice Files, Merrimack Education Center and Project SPOKE in Norton
- Computer Assisted Instruction, Merrimack Education Center
- Project COFFEE, Oxford
- Lawrence Children's Health Project, Lawrence
- Computer Literacy Institute, Merrimack Education Center

Many of these developments described were funded by Title IV-C during its school improvement focus. After review of several projects around the State and after discussion with several people directly involved with computer technology, the report presents lessons learned that should be of assistance to those contemplating the future development of computer technology in education.

Computer technology is very versatile and its use in the schools is expected to mirror the uses in the community and industry. This reflection on the society in which we live is becoming a necessity as schools change to meet the role of educating students to live in a computerized society. To aid in the fulfillment of this role, the report presents goals for educational uses of computer technology. There are several assumptions schools need to consider in planning for instructional technology needs:

1. Microcomputer capabilities continue to increase.
2. The number of microcomputers in schools and homes is increasing.
3. Computer literacy needs of general public are on the rise.
4. There is an urgent need for courseware, with accompanying teacher guides and student manuals.
5. Increasing support for computers in education has been shown by superintendents and boards of education.
6. More studies are required showing that use of computers in instruction raises achievement scores.

Richard J. Lavin
Executive Director

I
INTRODUCTION

The Age of Technology, the Computer Revolution, the Micro-Explosion - whatever the current trends in technology are called, there is a growing interest and an increased usage of technology in the educational field. Numerous school districts across the Commonwealth of Massachusetts have chosen to go beyond the slide projector, the calculator and the blackboard and are now using video tape equipment; cable TV communications; computers (mainframes, minis and micros); word processors; and other technologies to enhance the education process.

> Indeed a large portion of the Western World already can be considered a computerized society. Our task is coping with and using constructively the new social environment that is emerging as computers approach an era of virtually exponential growth.[1]

These technologies are being used in the classroom, the workshop, the laboratory, and the administrative office. With this being the case, the challenge is great for educators who must not only prepare students to enter such a world but who must themselves be prepared for teaching about computer technology. Some districts have not begun to tap technology resources while others have been able to make use of one or more technologies and have even developed district-wide plans for implementation.

Many changes will occur in the next few years both in the computers and in their use in schools. This report attempts to help decision makers in setting the direction for computer use in the future. This is done by summarizing several of the major computer projects in Massachusetts and by discussing some of the major lessons learned through those projects.

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1 Shane, Harold G. in "The Silicon Age and Education: in the Phi Delta Kappan. January, 1982. p. 303.

The importance of technology to education was clearly indicated by the Massachusetts Task Force on Instructional Technology when they stated that:

> The new forms education assumes will initially depend upon educator's ability to control the direction of the use of technology in education.
>
> In fiscal year, 1982, 41 percent of all LEA proposals to the Division (of Curriculum and Instruction of the Massachusetts Department of Education) for use of ESEA Title IV-B funds have included computer-related purchases. These proposals have expended 38 percent of the entire Massachusetts Title IV-B allocation on such purchases, and this represents only one source of funds.[2]

Because such a large portion of the Title IV-B funds (and for many school districts a not insignificant portion of their local budgets) has been spent on computers and computer-related systems, this report focuses on computer technology in Massachusetts, its status and future.

The report is organized to first provide a framework (Section II) for the reader. This framework outlines the terminology and the applications of computers. Then, examples of the major projects in Massachusetts are given (Section III) followed by a summary of lessons learned in Section IV. The background for Section IV was obtained by talking with many individuals around the state who are actively involved in the use of computers in education.

Acknowledgements

The author and the Merrimack Education Center acknowledge the assistance of the numerous individuals who contributed their thoughts and suggestions to this report. Special thanks are given to Clark Adams, Stacey Bressler, George Hanify and Inabeth Miller for their time and insights into the potential for computer technology in education.

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2 Report of the Task Force on Instructional Technology, May, 1982, p.4.

II

A FRAMEWORK FOR VIEWING COMPUTER TECHNOLOGY

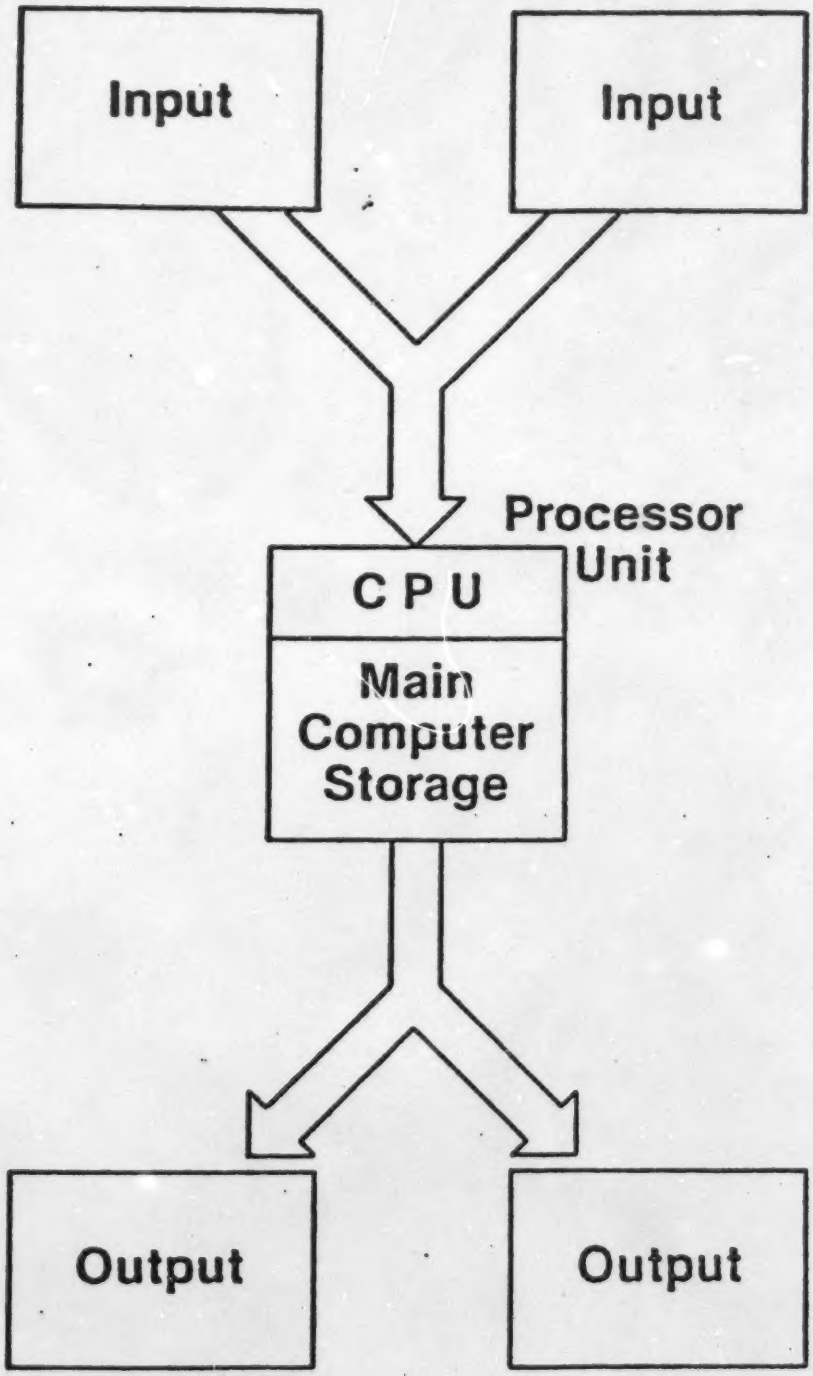
Before proceeding further, it is helpful to develop a framework for viewing computer technology. This framework is not a comprehensive tutorial but rather acts as an introduction to the following three areas: applications which are anticipated for computer; software terminology; and hardware components. A glossary of terms is included in Appendix A.

A. HARDWARE

There are many manufactuters of computer hardware. Consequently, there is a very large variety of hardware available and each month new equipment is being designed and placed on the market. The following is a brief description of the basic parts of a computer as stated in "A Guide to Instructional Microcomputer Software", reprinted by the Connecticut State Department of Education.

A computer is composed of four basic parts: the input unit, memory unit, central processing unit and output unit. The Central Processing Unit (CPU) is considered the "brain" that manipulates all information and performs all operations. All other components of the microcomputer have interaction with the CPU, as shown in the diagram.

DIAGRAM A


Input
Input
Processor Unit
C P U
Main Computer Storage
Output
Output

Computer Components

Here are a variety of devices that could be connected to a computer system.

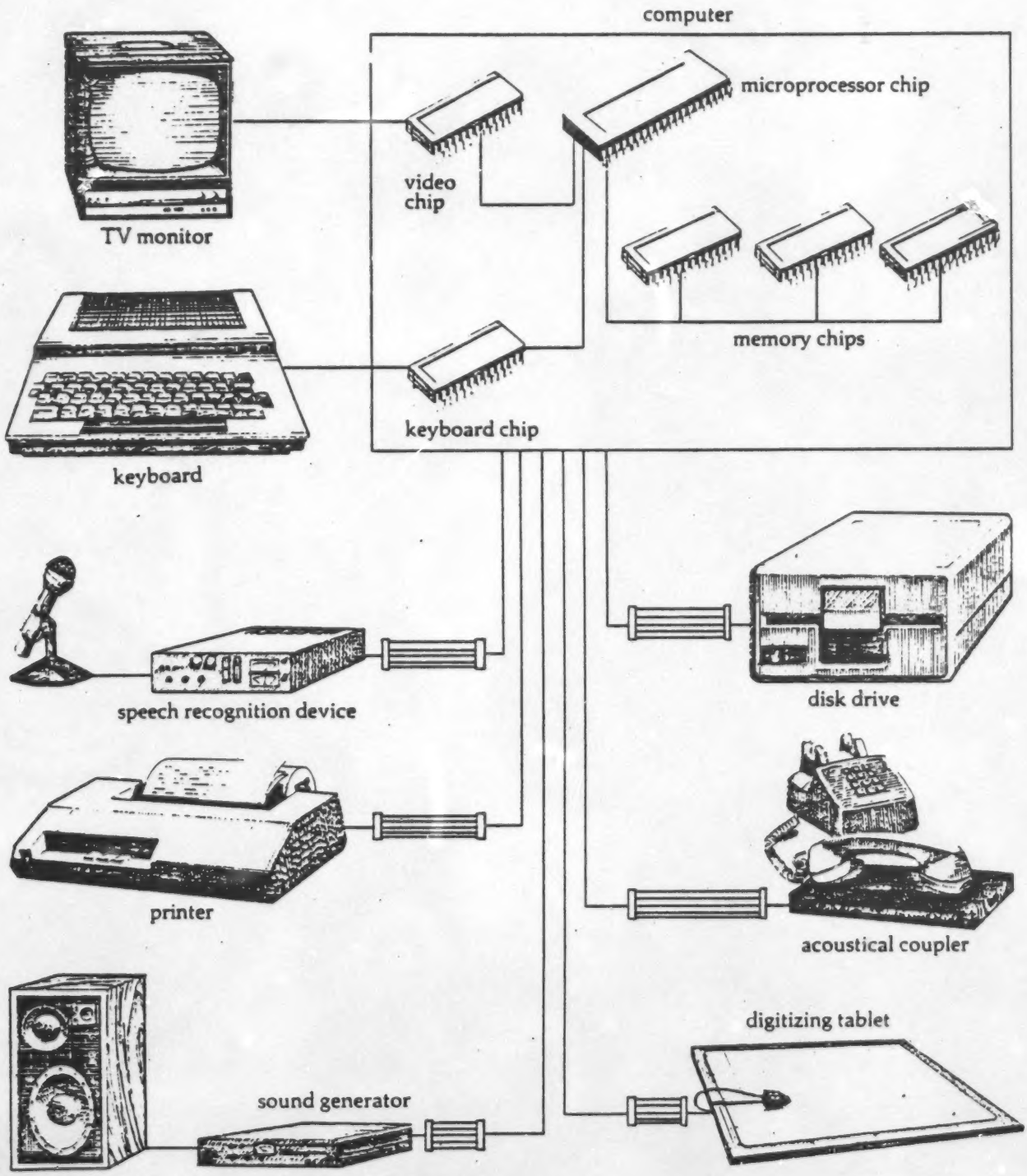


Diagram B identifies components of the microcomputer: keyboard, diskette, receiver and necessary cables to connect the microcomputer elements. The diskette unit is like recording devices (e.g., phonographs or tape cassette). CPU, or memory device, stores data and operating instructions. The "brain" of the computer can make calculations, store data for instructions, and process direct information. Other optional attachments, known as peripherals, can be added.

TERMINOLOGY

INPUT — Input is the way information is put from the outside to the inside of a computer for the purpose of processing. Inputs may also be in the form of cassette, floppy disk, magnetic card, CRT (Cathode Ray Tube), printer, or paper tape reader.

OUTPUT — Is often the same as the input mode. This is where processed information and results of calculations go out. Outputs are frequently CRT terminal, printer, magnetic tape, cassette, plotter, disk or other peripherals. Outputs can go through a telephone or cable line.

MEMORY — Is where information is stored. It can be found in two forms. It is found in terms of RAM or ROM. RAM is Random Access Memory which allows the CPU to store and gather data rapidly; i.e., 16K = 16,000 characters of storage. RAM can be erased and reprogrammed by the operator as frequently as necessary. Another memory is ROM - Read Only Memory. ROM is an integrated circuit on which data or instructions are programmed at the time of manufacture inside the CPU. It cannot be erased or reprogrammed by normal computer operations. All memory is stated in terms of bytes, such as 8K (8,000 characters) bytes of information.

CPU — The CPU conducts all information in and out of the other three parts of the computer. The electronic impulses from the other computer segments are sent to their necessary units by the CPU. The arithmetical logic performs all the arithmetical and logical operations. Such operations as addition, subtraction, multiplication, division and comparing are carried out in the log area. The CPU also takes care of such things as sorting and rearranging information such as alphabetizing.

Microcomputers in Use

A survey conducted by bureau staff from the Bureau of Education Resources[3], Massachusetts Department of Education, obtained information on the types of computers being used by schools in Massachusetts. The types of computers owned by the largest number of districts, in rank order, are as follows:

- Apple Microcomputers
- TRS-80 Microcomputers
- Digital Equipment Corporation PDP-11 Minicomputers

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3 Bureau of Educational Resources, 1982 Survey, Wellesley, MA, Summer, 1982. (222 out of 282 school districts responded)

Table 1, reprinted from the Bureau report, describes computer use in 282 school districts.

TABLE 1

COMPUTER USE IN MASSSCHUSETTS SCHOOLS*

Type of Computer	Total No. Reported	No. of Districts Owning Them
Microcomputers		
APPLE	836	123
TRS-80	703	105
PET	375	24
Other Commodore Microcomputers	157	18
Atari	69	15
Zenith	26	2
Heath	22	3
IBM Personal Computer	7	5
Texas Instruments	3	2
Other Microcomputers	57	8
Minicomputers & Mainframes		
PDP 11	70	64
WANG	29	22
IBM Mainframe	23	19
Digital Equipment Corp. Word Processors	14	6
Data General	11	11
PDP 8	9	9
Burroughs	6	6
Honeywell	5	5
NCR	4	4
Prime	1	1
Other Word Processors	4	4
Other Minicomputers & Mainframes	19	14

* Source: Bureau of Educational Resources, MDE

Several additional factors shed light on the discussion of hardware presented in this framework:

1. There are three general sizes of computers: mainframes, minicomputers, and microcomputers. (Diagram C)

   a. A mainframe computer has over 200 million characters of memory and can cost $150,000 or more.

	Large Computer Systems	Medium-Size Computer Systems	Small Computer Systems	Minicomputer Systems	Micro Computer Systems
Purchase Price($)	1-12 million	200,000-1,000,000	50,000-250,000	2,000-100,000	1,000-10,000
Main-Storage Capacity	Extremely large	Large	Medium	Medium	Limited
Ability to Support Numerous I/O Devices	Excellent	Excellent	Good	Fair	Poor
Processing Speed	Extremely fast	Fast	Moderately fast	Moderately fast	Relatively slow
Programming Language and Other Software Availability	Many options	Many options	Some options	Limited options	Very limited options
Environmental Requirements	Controlled environment	Controlled environment	Controlled environment	No special site prep	No special site prep
Computational Power	Very high	Very high	High	Relatively limited	Limited

DIAGRAM C

COMPARISON OF COMPUTER SYSTEMS

b. A minicomputer has between 50 million and 400 million characters of memory and costs anywhere from $50,000 to $200,000.

c. A microcomputer usually has between 8,000 characters and 128,000 characters of memory (internally) and costs anywhere from $2,000 to $10,000.

2. Microcomputers are the fastest growing portion of computer use in the schools as well as the largest segment of current use. There is a wide variety of microcomputers available on the market from numerous manufacturers, and the number is very likely to increase in the next few years. Thus, increased competition should continue to improve the cost features.

3. Before purchasing microcomputers and related peripherals, a school district should first consider the desired applications and software available to carry out those applications. If a school district already has a computer or computers, then the purchase of additional equipment should be made with care. Existing or new software may not be compatible with different hardware brands. Configuration of computers and new computers may prove more valuable when networked, rather than additions of competing hardware.

4. Computer hardware is much different today than it was even five years ago. Microcomputers are possible because of the silicon chip which has allowed the miniaturization of electronics. Hardware has continuously changed in this five-year period and these changes may continue in the coming years. There then may be a leveling off in fluctuations in hardware production for a time allowing software to develop at a faster rate than previously.

5. It appears that a major factor that will influence the development of hardware is the amount of information that a microcomputer's Central Processing Unit can process at one time. Most current computers have 8-bit CPU's; however, 16-bit CPU's are on the market and will be a major part of the next generation of computers. Thus, more information will be available at higher speeds.

B. SOFTWARE

Without effective software, no chosen hardware will be able to produce the necessary results. Whether a district requires a computer to support administrative word processing or to provide drill and practice in basic skills or to allow students to search through large databases, the chosen software must do what is specified or it will be close to useless.

Where the school district has chosen the uses for the intended computer technology, it will be necessary to determine what type of software is available to implement those desired applications. A report prepared by TERC[4] is very useful in helping educators to think through these decisions. That report also mentions numerous resources for finding and evaluating software, such as CONDUIT or MicroSIFT. TERC is also setting up a system for listing and evaluating software which should be very beneficial to the school districts.

There are numerous publications and magazines that list new software or provide evaluations of existing software. Before purchasing software, it is desirable for the school district staff to review the available products using any number of evaluation techniques available. These suggested methods of evaluation are contained in reports such as "A Guide to Instructional Microcomputer Software,"[5] reprinted by the Connecticut State Department of Education, the TERC report previously mentioned, or the book Practical Guide to Computers in Education, by Peter Coburn, and others.[6]

But as these publications will point out, many experts agree that there are not enough software packages available and much of the software is not of high quality. There is more software today than in the past but it is difficult to find good software for all applications. There should be an increase in the available software in the coming months and

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4 Naiman, Adeline, "Microcomputers in Education: An Introduction," Northeast Reg. Exchange & Tech. Ed. Research Center (TERC), Chelmsford, MA, 1982

5 Douglas, Shirley and Gary Neights, "Instructional Software Selection," Pennsylvania Dept. of Education, Reprinted as "A Guide to Instructional Microcomputer Software," by the Conn. State Dept. of Education.

6 Coburn, Peter, et al., Practical Guide to Computers in Education, Addision-Wesley Publishing Co., Reading, MA, 1982.

pressure from educators who carefully review their needs will just mean that the new products are better in quality. Additionally, as hardware design showed an early spurt of development, software writers are now attempting to get many more new products onto the market, while hardware is going through refinement. The tremendous cost of producing instructional software, and the developer's entitlement to production royalties in the marketing and distribution of software are still major areas of concern.

A complication which has furthered the problems of software development may also be resolved--the issue of compatibility. Most software can only operate on one brand of equipment and then not on all models of that brand. This incompatibility limits the choices that educators have; however, manufacturers have recognized this problem and are beginning to respond.

Another trend in software that will have a big impact is the addition of more tutorial and simulation to complement drill and practice instruction. This trend will move educators toward interactive software designed to make students think, enquire, and act in different ways for development of cognitive skills and problem solving. Color, graphics, and sound are all part of this new software. These trends in software are now being realized and they will have extremely beneficial impacts on the applications of computers in education.

C. APPLICATIONS

There are many who suggest that the application of computer technology will be limitless in the years to come. Just as computers are becoming ever-present in society, in the supermarket, the bank, and the retail stores, business and industry, so too may they become a part of the educational scene.

There are two major categories for the application of computer technology in education: instruction and administration. A very good summary of these applications is given in the TERC report.

The survey conducted by the Bureau of Educational Resources also obtained information on the uses for computers in Massachusetts schools. More than 80 percent of the schools reported using computers for instruction or classroom management. The heaviest use of computers is at the secondary level, and computers are used most frequently for the teaching of mathematics.

It is helpful to get a view of the prevalence of these applications in Massachusetts' school districts.[7] The major uses of computer technology as reported by the districts on the Massachusetts Dept. of Education report, include the following:[8]

TABLE 2

APPLICATIONS IN SCHOOL DISTRICTS

USE	NUMBER OF DISTRICTS
General Instruction	183
Mathematics Instruction	162
Management of Student Records	103
Word Processing	94
Scheduling of Students/Staff	87
Report Cards	87
Special Education (Instruct. & Admin.)	84
Gifted and Talented	81

Thus, it can be seen that a broad use of computers is now being realized in Massachusetts schools. Of course, the Massachusetts Department of Education report does not show the total number of districts using computers nor does it show overlapping uses within a district, nor schools using multiple applications. Still, the trend toward a varied use of the computer is evident in Massachusetts school districts.

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7 Computers are used in 92% of schools as reported by an ERS nationwide sampling survey (89% of districts reporting use for administrative purposes and 77% for instructional purposes). This nationwide sample for microcomputers reported 45% Apple followed by Radio Shack/Tandy TRS-80 at 44%.

8 Bureau of Educational Resources, M.D.E., op. cit., 1982

It is the responsibility of each school district to analyze and determine which applications will help it to meet its goals for its students. If a district has adequate means for attendance monitoring, then it should eliminate that application from consideration. Without this narrowing of focus and specificity, the district will not be able to clearly define software and hardware requirements and will be attempting to get a system that does all things for them. This is not practical.

There are a number of aspects of computer applications that will be growing over the next several months and years. The only limiting factor appears to be the creativity of educators in devising new uses. For instance, word processing is already beginning to be used not only for administrative purposes but also instructional uses in teaching composition. Letters and reports for busy administrators are effectively handled by a word processor, while students also can learn writing skills and text editing on a word processor. Further, word processing can be performed on separate word processing machines or can be part of a microcomputer. The latter would provide for more flexible use because other administrative or instructional uses are possible for the computer. Examples: calculation, tool application, graphing.

Another application of computers which is receiving increased attention is the field of graphics. Some computer software and hardware configurations currently allow for effective use of graphics--often in color. This use will continue to expand as better and more versatile graphics capabilities are added to computers. Students will quickly be able to visually and some times dramatically see the results of their work. They will be able to make immediate changes to reflect corrections or differing directions in their work. Similarly, the increased use of sound will make music theory as well as other symbol-sound applications a valuable learning experience for the students of the near future.

One of the most exciting applications being developed for educational computers is the wide area of databases. Already many home computer owners are tapping into national databases through cable TV (for encyclopedia data, for weather reports, banking & financial data information, sports scores, and many other informational sources). It is only a matter of time until educators make use of the potential for storing vast amounts of data on the computer or for networking with other databases built by other schools. Students will be able to search for information on Presidents or cross-reference data on scientific problems. Bibliographical searches such as ERIC and School Practices File[9] are only the forerunner of these types of databases.

In conclusion, this Section has briefly described a framework for approaching the use of computer technology for education in Massachusetts. The basic components of a computer system are the hardware and software configurations necessary to meet the applications defined by the school district. Effective planning can help a school district to clearly define needed applications and will lead to the development of a computer system that will most effectively meet the needs of students.

There are useful publications that are very thorough and which are highly recommended reading for those interested in pursuing computer technology. In fact, these publications, as well as the many Computer Literacy Courses now being offered around the Commonwealth, are recommended for all educators who want to keep up with the changing technology which will be affecting schools in the coming years as much, if not more, than it will be affecting the society around us. (See Appendix B for a partial listing of resource locations.)

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9 SPIF--School Practices Information File published by Bibliographic Retrieval Services, Scotia, New York, and RICE--an information and indexing system for software descriptions.

III

EXAMPLES OF COMPUTER USE IN MASSACHUSETTS SCHOOLS

There has been an exciting growth of computer use in Massachusetts schools in the past four years.[10] As the previous section indicates, a large number of school districts are using computers for a wide variety of purposes, including word processing, management of student records, and special education, as well as instructional purposes. Specialty uses include inventory, energy management, and transportation lists. As more and more uses are demonstrated by enterprising districts, other districts will learn from those experiences and begin to use computers too. Those districts already utilizing computers will continue to find more and diverse uses for these flexible and powerful tools. Computer technology applications are expected to increase over the next several years.

It would be difficult to summarize all of the activities throughout the Commonwealth. At the same time, any effort to review selected programs in selected cities or towns runs the risk of omitting important work in the districts not reviewed. Numerous towns have been mentioned during the source of research for this report. Many undoubtedly have exemplary computer activities. These include Weston, Lincoln, Lexington, Quincy, Brookline, Andover and many others.

This report, however, does focus on several projects which have major outside funding, primarily from Title IV-C. Two of the projects chosen have been nationally validated. The projects cover a range of computer uses, including teacher training, curriculum development, computer assisted instruction and administrative uses. In addition to this report, these projects have descriptive and curriculum documents which are available directly from the project staff. Appendix B lists the addresses and contact persons for each project cited in this report.

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10 See also, the directory of computer uses recently compiled by the staff of the Gutman Library of the Harvard Graduate School of Education.

The following are the projects summarized in this report:

A. Project CAPTURE, Uxbridge
B. Project LOGIC, Hampshire Educational Collaborative
C. Education Programs and Practices File, Merrimack Education Center
D. A Network of Practice File, Merrimack Education Center and Project SPOKE in Norton
E. Computer-Assisted Instruction, Merrimack Education Center
F. Project COFFEE, Oxford
G. Lawrence Children's Health Project/EPSDT, Lawrence
H. Computer Literacy Institute, Merrimack Education Center

A. Project CAPTURE -- Uxbridge, MA
Computer Aiding People to Use Reflective Inquiry
Funded by Title IV-C, 1979-1982; Adoption grants funded for 1982-83

This project provides an introduction to computer programming for all students and in-depth training and practical experiences for able students. Eighth grade math classes include a two-week programming unit. Students identified as interested and capable enter a ninth grade independent study course designed to help them become competent programmers. Detailed curriculum guides were developed by the Project for teachers and students and are available to all schools adopting the project with Title IV-C funds.

The project was validated through the Title IV-C validation process in 1982. This validation has given extra support to the effort to disseminate and reproduce the project in other school districts. Thus, others are beginning to learn from the experience of those in Uxbridge. Currently, several sites have been funded and as many as 1,000 teachers could be affected by these new training efforts. Teachers all learn BASIC and then use the curriculum manuals to teach their students.

Project CAPTURE identifies talented youth and/or those with a strong interest for learning computer skills. Extra-curricular, enrichment work is offered in a course designed to develop skills for computer programming. Personal student use of microcomputer is also taught and students assist teachers in the applications of computers, microcomputers and general awareness units for the middle school.

The introductory segment of the course at the middle school level is offered in a two-week segment for all eighth grade students enrolled in math. Hands-on experience in programming is provided and career exploration is encouraged. Non-traditional careers for women in the field of computer science are explored. Gifted and talented students in grades 5-12 are identified who then develop skill in using microcomputers as a tool for divergent thinking and creative problem solving. Inservice education is provided in summer periods and workshops and seminars are scheduled throughout the school year.

B. Project LOGIC -- Hampshire Educational Collaborative
Funded by Title IV-C, 1980-1982

This project has developed training models for helping teachers meet a wide range of student needs, both in the classroom and in the development of curricula. Emphasis is on giving teachers the ability to develop student's minimal competencies with a population in grades 5-8.

Several major components of this project are:

- Teacher training in computer programming.
- Regional resource center for paper and electronic information.
- "In-Classroom" support to teachers.
- Technical assistance before and after procurement of computer systems.
- Familiarization program for special education students.

The Hampshire Educational Collaborative developed a training program that would help teachers to be more effective teachers of computer science. Each of six program components can be adapted individually in a modular format. These six training modules include:

1) COMPUTER LITERACY FOR TEACHERS: An introduction to how computers work, the three computer languages usually used in schools, and educational software.

2) LOGO: A language designed for learning. Among its many applications, LOGO has been used to teach reading to three-year olds and physics to college students. LOGO mastery also deepens the student's understanding of how computers work.

3) BASIC: The educational language with real world applications. BASIC was the first language widely taught at the secondary level. It still is widely used in business and industry.

4) PILOT: The "authoring" language. PILOT makes it easy for teachers to write their own programs for computer-aided instruction. It provides a painless graphics and music option. Teenagers like it, too, for writing adventure games and quizzes.

5) SOFTWARE: How to choose among the hundreds of educational computer programs on the market. (Most of them are not too good.) How to locate software reviews...how to set up a software exchange...how to institutionalize software evaluation in your school district.

6) KEEPING ONLINE: Computer education is an innovation that changes every day. New machines are invented, new programs are written and new classroom applications are designed. Educators can keep up-to-date through the appropriate strategies, organizations and literature.

C. Educational Programs and Practices File -- Merrimack Education Center
Funded by Title IV-C, 1981-1982

The Merrimack Education Center obtained funding for this Project after recognizing that through the process of sharing and exchanging promising practices, local school districts can expand their available resource base for school improvement efforts.

The goal of this Project is to facilitate programmatic improvements in schools through the identification and exchange of practices in curriculum, inservice training or other major priorities. This project represents a milestone in using the most advanced information management technology and effective means of educational exchange for school improvement.

A microcomputer-based information system was developed to catalog the programs and practices which have been collected. This file covers a wide variety of validated and non-validated programs. Project descriptions are coded and stored on discs for easy access and updating so that programs can be located by key subject area. In addition, MEC

has obtained all educational curriculum materials available through the Minnesota Educational Computing Consortium and is distributing that software on diskettes with supporting documents. Curriculum guides from school districts in Massachusetts are also added to this file for exchange.

Several validated technology projects from around the nation share resources and exchange program and practice information. Descriptions of successful practices from the following projects can be made available.

D. A Network of Practice Files - Merrimack Education Center and Project SPOKE, Norton, MA, and Evaluation Resource Center, Amherst, MA Funded by Title IV-C, 1982-1983

To effectively disseminate the information being gathered for the Practice File, the Merrimack Education Center (MEC) links with two other sites where all the information mentioned in Item (C) above will be available. These two sites are connected to the MEC base in Chelmsford via telecommunications. Any new materials that are added to the file can be added quickly at each site on disks for the Apple II. Users may visit any site or may call in and, through the appropriate telecommunications link, may review materials on their own microcomputers.

This project features the following components:

- Broad based programs and practices file available in three sites state-wide: Project SPOKE, Norton; the Evaluation Resource Center, Amherst; and MEC, Chelmsford.
- Files are stored on microcmputer for exchange on diskettes for Apple II.
- The three sites are linked with each other through telecommunications.
- Other school districts will also access data through telecommunications, or by visiting one of these sites.

E. Computer-Assisted Instruction, Merrimack Education Center Funded by Title I, 1978-1982.

This Project is conducted in sixteen school sites in six school districts in the Merrimack Valley as part of the regular ESEA Title I (Chapter I) programs. The use of CAI in these compensatory education programs is predicted on the assumption that its unique properties can produce achievement gains over and above those which are characteristic of conventional approaches to Title I (Chapter I) instruction. CAI has proven to be an effective means of increasing the reading and mathematics knowledge and skills of Title I children and its adoption on a much wider scale is being carried out through a National Diffusion Network (NDN) and Lighthouse grants from the Department of Education, Washington, D.C.

The principal strategies employed in pursuit of program goals are these:

1. Turorial or small-group sessions for each child.
2. Complete and appropriate use of diagnostic measures for all students on the Nova IV minicomputer.
3. Use of specific, behaviorally-stated objectives against which program progress can be measured.
4. Allowing each student to progress at his or her own speed.
5. Inservice training for faculty.
6. Individual student interaction with the CAI system on a daily basis for approximately ten minutes.
7. Use of additional system generated diagnostic information about placement and progress within curriculum strands for teacher evaluation and modification of learning prescriptions.
8. Optional entry levels depending upon initial experience and CAI system diagnostic routines.
9. Widely varied curricula for enrichment depending upon student needs and capabilities.
10. Summative and formative evaluation information generated continuously by the CAI system.

Regular evaluations of this project consistently showed a positive affect on students. In June, 1982, the Project applied for and received national validation and is currently preparing for dissemination and adoption activities.

F. Project COFFEE - Oxford, MA
Funded by Special/Occupational Education, 1979-1982

As an alternative to the traditional high school curriculum, Project COFFEE offers occupational entry skills and job placement as a work study program. Students learn electronic assembly and skills training in layout and assembly of printed circuit boards.

Data processing provides skills training for the Data Processing Center. Such careers as computer operator, data entry operator, computer programmer and word processor are offered as part of the technical training.

G. Lawrence Children's Health Project/EPSDT - Lawrence, MA
Funded by Massachusetts Department of Public Welfare and Massachusetts Department of Public Health, 1979-1982

A comprehensive student health record system was designed and implemented as part of this national demonstration of a school health and health screening program. Prior to the implementation of the LCHP Health Record System, all health records in Lawrence were kept manually by school nurses in an often inconsistent manner. Updating records, tracking children with incomplete immunizations, and transferring student records from one school to another were all activities which took a great deal of the nurses' time.

Consider the need to keep track of 8,000 students; the need to know what school they are in; whether they have had the required physical exam; whether they have been properly immunized; and whether they have received the necessary vision, hearing and posture screening.

This was the need that had to be met by the Lawrence Children's Health Project (LCHP) during the 1981-1982 school year. For two years the Project had been providing physical exams to Lawrence school children. In order to allow more coordination between the LCHP and the school health program as well as to provide supervision for school nurses, the superintendent gave responsibility for the school health program to the Project in the Fall of 1981.

The Project had previously experimented with a minicomputer health record system for its own data and management needs. It had been determined that this system would be too costly to purchase ($80,000 for hardware) and yearly costs would also be high ($20,000). Thus, an alternative system was sought and a microcomputer based system was designed that would include management needs of the Project as well as the health record needs of the school health program.

The Project compiled a paper reporting on the success of that demonstration. Using a data-based management language known as dBASE II the microcomputer system is an extremely important tool in managing the school health records.

Lawrence High School students are coded and entered on a minicomputer. During the 1982-1983 school year, all students will be entered on this computer and attendance and grades will be centralized. With minor adjustments, the LCHP Heatlh Record System will have data (i.e., IDNO) compatible with this minicomputer system. The health records will remain separate because of limited storage space on the minicomputer; ease of manipulation by the microcomputer; and because the uses of the two sets of data are very different and, therefore, combining the data is not really required.

H. Computer Literacy Institute, Merrimack Education Center
Funded through User Fees, 1981 - Present

Unlike projects which used Title IV-C funds to establish a teacher training program, this on-going institute relies on user fees, primarily school districts which pay for teachers and administrators to attend. This three-day hands-on institute brings teachers and administrators up

to current state-of-the-art in hardware and software. It also includes work sessions for strategic planning for district or classroom use of computers.

Topics covered in the institute incude:

- Computer Hardware
- Peripherals
- Memory
- Comparison of Microcomputers
- Planning Issues (maintenance, security)
- Software for the Classroom
- Software Demonstration
- Evaluating Software
- Programming Languages
- Graphics
  Curriculum Design

The Institute includes hands-on experience on minicomputers and a variety of microcomputers.

Other validated programs nationwide are shown in the following listing.

VALIDATED BY JDRP, U.S. DEPARTMENT OF EDUCATION

1. Project CAM mastery management and achievement monitoring.
2. I Pass--individualized prescription arithmetic skills.
3. CAPP--computer-assisted prescription programs for reading and math.
4. Gifted Child Project--computer literacy for the gifted.
5. Individualized Computer-Assisted Remedial Education--reading and math with vocational focus.
6. CAI--Computer-Assisted Instruction (CAI) courseware for students K-12.
7. Computers for Secondary Math--math modules for algebra and other high school math courses.
8. COFFEE--career awareness and skills training for high technology with a student work-study component. CAI is used to teach basic skills at secondary level.
9. Calculator Math--hand-held calculators are used as part of the existing math program to improve computation skills.
10. Calculator-Assisted Math--general math students learn skills in 21 modules over a two-year time frame--to improve skills, concepts and applications.
11. Project Clover--educational and medical records are maintained for migrant students. Test data and information on curriculum are also in the system.
12. Special Education MARRS--for students 4-6 grades with minimal hearing loss, the technology provides amplication of the teachers' voice.

NATIONALLY VALIDATED--ADMINISTRATIVE PRACTICES

1. Cashflow forecasting to make investment and loan decisions and then project cash balances.
2. Simu-School--models facilitate planning for simulating budgets and projections.
3. Pupil Attendance and Census--reports can be generated on a daily attendance, and other statictics--annual census, and other management reports.

IV

A SUMMARY OF LESSONS LEARNED IN COMPUTER TECHNOLOGY

The previous examples of computer uses in Massachusetts schools can provide lessons for making decisions about future uses for computer technology. The following are some general goals for educational uses of computer technology in the future. Then, the next few pages state some lessons which can be drawn from the experience of the projects referenced in this report.

Goal One: As computers become a major part of our society it becomes very important for educational systems to include training in computer literacy for all students.

Goal Two: To become more efficient and more effective with limited resources it is necessary for educators to make use of computers for the daily operation of school systems.

Goal Three: Teachers must become more aware of the capabilities of computers and must be prepared to seek out appropriate programs to aid in the educational process.

Goal Four: Adequate financial and political resources must be devoted to the implementation of computer education.

These factors raise needs around three key service components for MEC:

1. Staff Development
2. Curriculum and Instruction
3. Technical Assistance

LESSONS LEARNED

1. Teachers want to gain skills in advanced areas of computer knowledge and applications; indeed, many of them want to learn programming languages.

However, not all teachers are expected to program. They aren't expected to write their own textbooks. Project LOGIC emphasizes programming in the courses they offer to teachers pointing out that if teachers are comfortable as programmers then they will be better teachers of computer programming. If a teacher learns to program, then there is a better understanding of the machine and the way it functions which can lead to better teaching.

Another question to ask is whether or not students should be expected to learn to program. At Project CAPTURE, the emphasis was on teaching older students to learn to program using BASIC. Teachers are given training and classroom support and manuals were developed to help the teachers as well as the students.

If a student's exposure to computers is for drill and practice or for interactive games or other non-programming activities, then the teachers could be expected to learn to use the computer for these activities but not necessarily learn to program.

The substantial gain observed in the MEC CAI program with six local school districts shows the need to establish CAI laboratories in elementary and middle schools. A complete course sequence, leading to a fully trained and computer literate staff, can support the school district's objectives. A substantial course in computer literacy should be part of every teacher's inservice training. And, for those willing to pursue graduate training, a comprehensive program leading to expertise in programming can be made available.

Suggested training programs include:

- Workshops in specialized areas to develop computer skills. Subjects such as LOGO, BASIC, Graphics, Programming.
- Workshops for school business officials in conjunction designed to introduce Energy Miser, Bursar, additional software for business practices.

- Training teachers of gifted and talented to incorporate use of computers into such programs; other special education applications.
- Training educational secretaries in use of Word Processing using microcomputers.

2. Software choices must be made based on planned curriculum focus and must precede hardware decisions. This is a true statement to the extent that the school district has no (or limited) existing computer hardware. As compatibility becomes less of a problem in the future all choices can be made this way. But there is nothing wrong with having different computers for different uses--e.g. inexpensive ($99. to $299.) computers are now available which could be used very nicely for teaching BASIC. Many of these could be purchased in order to maximize hands-on experience for students at the minimum cost.

   It is true, however, that it is hard to preview software without having the hardware in house. A lot of time can be wasted traveling around to various locations to test out the software. This speaks for the need for at last two solutions--collaboratives, libraries or other organizations can act as repositories for software and can allow teachers and administrators to test the programs. Another solution is to allow teachers to have time to test software outside of the classroom. Merrimack Education Center maintains an extensive software library at its Computer Learning Center. These software materials are also available at the Title IV-C Evaluation Resource Center in Amherst.

   There is a demonstrated interest on the part of communities to continue commitment and support to the applications and implementation of instructional technology. Special expertise in curriculum areas is needed in each local school district to identify technology applications and build capacity for choosing

and implementing technology. Software identification and provision of courseware and related support promote the use of instructional technology through several planned activities.

- Establish software library to assemble, duplicate preview and review educational software.
- Disseminate Project CAPTURE and other validated projects for teaching BASIC at the junior high/middle school level.
- Develop curriculum using Word Processing to teach writing skills in the basic skills of composition and text editing.

3. It is extremely important to clearly define the need--in terms of applications to be implemented in a school district, in terms of the software capabilities which are required to provide those applications, and in terms of the hardware to implement the entire package. The planning process should include everyone who potentially will be affected by the system and the planning should take place over a period of time sufficient to do the job. The need for improved teaching models, particularly in basic skills, and the increase in the quality of computer-assisted instructional programs highlight the need to implement quality software into classroom instruction. The extremely wide and varied range of student abilities in today's classrooms requires the classroom instructional management that only a computer can provide. Attempts at individualized classroom instruction often fail because of limitations of teachers. The increase in class sizes because of the limited resources mentioned demand the implementation of computers to provide individualized instruction.

4. Limited resources are a result of decreases in local, state and Federal funds, and will continue for several more years. At the same time, computers are decreasing in cost and increasing in capability. The introduction of computers will give greater return on each budget dollar and show cost-effectiveness.

5. There are numerous journals and resources available which list and evaluate software. There is no excuse today for not being able to find out what software is available for a particular job. These resources are continuing to grow and are readily accessible. School districts should make these publications available to the group which is interested in purchasing software. Further, many collaboratives, libraries, and other organizations are now in the business of cataloging software for educators with review and analysis of software through on-line data bases.

   There is still a lack of quality software for many of the applications which are planned. But there is a growing amount of software and a definite ability to know what is available and what each program is capable of doing.

6. Administrators and principals are having much more impact on decisions about computers than they did in the past. This affects whether or not computers will be purchased, what they will be used to do, and who will be able to use them. This is in part due to the "coming of age" of computers in education as well as the fact that more and more, the local school budget is being used to obtain computers.

   This focus for decisions means that there must be adequate training for these decision makers. Building administrators need to know the capabilities of computers and the limitations of the various configurations--they do not need to be capable of using computers themselves. Further, these people must know the role of computers in relation to other aspects of the curriculum and they will be expected to balance requests for various curriculum materials, including computers.

7. At the elementary level there is usually a great deal of student/teacher interaction and working in small groups. This type of activity as well as the need for extensive hands-on experience (time alone or in small groups to interact with the computer either for programming, drill, interactive games, or whatever) will be needed if there is to be an effective implementation of the computer technology. At the junior high and high school level, the lecture style is more prevalent. This then is where changes may need to occur if implementation is to be dramatic.

8. If computers are to be used in education something else must give way to make room. This would be true of any new curriculum or technology which is introduced. It is not always possible to determine ahead of time what will be dropped in deference to the new activity. Project LOGIC participants had hoped to keep doing everything that they had been doing and add to that the computer programming. This did not occur. Thus, teachers, administrators, parents, and school committee people should be aware that these changes will take place and they must attempt to plan for them the best they can, to see that essential skills are integrated and maintained.

9. What is the relationship between the school and the home in the new age of computers in education? Many parents are demanding computers be used in the schools. Many parents have the desire and the expertise to help schools in the planning and implementation of computer systems. And, many homes have computers that are giving those students an advantage over students without computers.

   Additionally, computers are affecting every aspect of society and some level of computer knowledge is needed by all to cope with the technology. Should schools offer training in computers for parents as well as youngsters? Project LOGIC helped to start community computer training. This can benefit not only the parents but can improve their interaction with children and help to reinforce the comunication between parents and children around issues of computers and perhaps affect other areas as well.

Further, will students who don't have computers at home be allowed to take school computers home? Or, to use the buying power of the school to help reduce the cost of buying a home computer?

10. Computers can be very versatile when applied to administrative situations as well as instruction. This is evident in the many administrative uses listed in the Massachusetts Department of Education and other national surveys. Can schools effectively teach students about computers if school staff do not use computers regularly themselves for administrative matters? If the pencil is still the major tool of the school personnel they will not be able to communicate effectively about the role of computers. Further, as resources continue to shrink for school purposes it is advisable for school administrators to find ways of using the computer to make the educational process more efficient. The overlap between the administrative uses of the computer in the school and the business uses of computer in commercial endeavors means that there should be no end to the potential software and demonstrated effective systems. There are plenty of demonstrated uses which can be adopted by others to bring school administration into the computer age.

11. Computers in the classroom should approximate the real world uses of computers. That is, computer use in the real world is not by any means a programming activity. School graduates do not need to know how to program to be comfortable with computers. But, they do need to be exposed to the uses they may encounter when they graduate--either because their job, their bank, their grocery store, or even their own home may rely on computers. Students interested in accounting should be exposed to real accounting situations. Computers can provide simulation activities which approximate the real situation which students may face. This clearly is an age dependent situation because younger students can not be expected to learn sophisticated accounting techniques nor do they need to know complex accounting computer programs. But, there is an increasing number of software products which can be used at all levels to

provide real life activity. The speed and capability for immediate feedback which is provided by the computer allows for not only activities which approximate real world computer applications but which approximate real world situations in all walks of life--e.g., the SEARCH Series.

12. Networking is going to be a key feature of all successful computer applications in the future. Networking is basically the linking of separate entities for the purpose of transferring information. These entities can be school districts which are linked for sharing software or curriculum materials. The entities can be computers linked to each other via telecommunications for transferring information or, the link can be between computers in the classroom, controlled by the teacher's computer. Telecommunications currently links Merrimack Education Center, Amherst Title IV-C Evaluation Resource Center and SPOKE. Elaborate data bases have bulletin boards that enable rapid communication of events. These can be used as examples.

    Numerous networks have been established for the sharing of information. Most have been linked by use of paper products. In the field of education it may be time to make those links electronically in order to speed the transfer of data.

13. It is clear from the previously mentioned projects that there is and will continue to be a need for technical assistance to school systems. Whether this assistance comes in the form of teacher training, specification design, after purchase support, software evaluation and cataloging, or any other mechanism, the technical assistance will be needed to assure that decisions are made properly and that implementation is effective.

14. There are as many ways of funding computer technology as there are school districts in the Commonwealth. Some of the referenced projects used federal grant money to get them going. Others used state or local governmental finances. Still others were successful in utilizing user fees to fund operations. Private foundations have been tapped and many manufacturers have

corporate contribution mechanisms. All of these, and more, are possible ways of assuring that computer technology can be adopted in the educational field.

On conclusion, there are many things to be learned from the experience over the past few years in Massachusetts schools. Other reviewers may look to other projects and programs in the state and find yet other lessons. As the field of computer technology continues to become a part of schools it is incumbent upon educators to learn from the past and not to be afraid to look into the future and make use of the potential which lies beneath the surface of existing uses of computers.

The challenge of computer technology in education is one that will be exciting to be a part of and one which will be important to many students' lives and to the structure of society in the coming years.

Recommendations for Planners

1. Each school district should have an organized policy for computer instruction across the curriculum to articulate across the grades and across subjects.

2. A substantial course in computer literacy should be a part of every teacher's inservice training. This course should contain specific competencies related to the following:

   a. Knowledge of support systems

      -availability of software
      -development and production of software/courseware
      -equipment specifications

   b. Designing instructional units

      -review curriculum and instructional units; objectives and courseware
      organize course content (branching, networking, sequencing)

c. Evaluation and learner verification

reporting systems; monitoring progress
course maintenance
validation of all new software and instructional techniques

3. To provide this systematic training and program development, the local school district must see that there is access to adequate numbers and types of hardware to accomplish these goals. Updating obsolete equipment is an added responsibility.

4. Practitioners want to gain skills in advanced areas of computer knowledge. Meetings, conferences, and courses further this knowledge and awareness of what is current and under development. School districts should support the development and presentation of such conferences, workshops and training programs offered by regional service centers.

APPENDICES

APPENDIX A

GLOSSARY OF MICROCOMPUTER TERMS

by

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Acoustic Coupler	An attachment which allows a computer to send and receive information using telephones. See also MODEM.
Alphanumeric	A character which is a letter or a number.
Apple	A popular brand of microcomputers using the Mostech 6502 chip.
ASCII	American Standard Code for Information Interchange - A standardized system of binary numerical representation used by computers for generating letters, numbers and special characters.
Atari	A brand of microcomputers using the Mostech 6502 chip.
Authoring Language	A collection of programs which enable the user to use English language instructions instead of programming language to communicate with the computer.
BASIC	Beginners All-purpose Symbolic Instruction Code - A popular programmming language which has become a standard feature on almost all microcomputers. BASIC uses English-like commands and was developed in 1963 at Dartmouth College by Kemeny and Kurtz.
Baud	The number of bits per second which can be transmitted or received.
Binary	A base two number system (as opposed to decimal which is base ten) where all digits are either 0 or 1. Binary is the system used internally by computers.
Bit	Binary Digit - The 0's and 1's which are used by the microcomputer to generate letters, numbers, etc. A bit is the smallest unit for information storage.

Bug	An error in either hardware or software which prohibits a program from doing what it was designned to do.
Byte	A series of bits (eight in most microcomputers) which are strung together to represent a single letter, number or special character. Usually a byte is equivalent to one keystroke on a typewriter. Microcomputer memory size is measured in bytes.
Chip	A tiny piece of silicon which contains thousands of electronic circuit components.
COBOL	A programming language developed for business applications which is available on some microcomputers.
Code	Information written in computer readable form.
CP/M	A standardized operating system which allows program sharing among some Z-80 based machines.
CPU	Central Processing Unit - The internal part of a computer which controls its operations.
CRT	Cathode Ray Tube - A television-like screen used for display of computer input and output.
Commodore	Manufacturer of business machines, including serveral microcomputers.
Data Base Management	A program or collection of programs designed to structure information to facilitate storage and retrieval.
Disk, or Disc	A piece of magnetically coated material on which information can be recorded and stored. Most microcomputers use floppy disks which are flexible, as the name implies. These small floppy disks are also called diskettes. Hard disks, which are not flexible and can hold more information, can be connected to most microcomputers.
Disk Drive	A piece of hardware which allows information to be recorded on or read from a disk.
Documentation	Written descriptons of software and hardware.
DOS	Disk Operating System - A collection of programs which enable the disk drive to operate effectively.
Editor	A program which facilitates modifications or change in programming statements or text.

Firmware	A type of software which has been made part of the computer and cannot be accessed by the user, therefore, functioning as though it were hardware.
Fortran	A programming language developed for scientific applications which is available on some microcomputers.
Hard Copy	Computer output which is printed on paper, thereby becoming more permanent than the temporary CRT display of output.
IBM	A huge company which has recently added a microcomputer line.
Initialize	To prepare a disk for storing information.
Input	Information fed into a computer. Usually input is used together with output.
I/O	Input/Output - Usually used as an adjective describing a device which is used for entering and/or displaying information. Printers, keyboards, disk drives and CRT's are all I/O devices.
Interface	A circuit which allows other devices to be connected with a computer.
K	Kilo - One thousand, memory size is usually measured in K's of bytes (for this application, K is actually 2^{10}, 1024, rounded-off to 1,000).
Keyboard	A typewriter-like arrangement of keys used to enter letters, numbers and special characters into a computer.
Language	A standardized set of instructions which allow a user to create programs to direct the operations of a computer.
LOGO	A computer language developed at MIT specifically for use with children.
Memory	The circuits which allow a computer to store information. See also RAM and ROM.
Menu	A list of options within a program which allow the user to make selections. Menu driven software can be more flexible and still be well-suited for a user's specific application.
Microcomputer	A computer which uses a chip for its CPU
Microprocessor	A chip which can execute instructions.

MODEM	Modulator/Demodulator - A device which converts digital information into musical tones (modulates) and tones into digital information (demodulates) to allow computers to communicate via telephone.
Monitor	A television set that has been adapted to receive signals directly from a computer.
Ohio Scientific	Company which produces microcomputers, as well as other equipment.
OS	Operating System - Software which assists the user in controlling some computer functions such as the operation of I/O devices.
Output	Information coming out of a computer. Usually, output is used together with input.
PASCAL	A programming language developed for computer scientists which is often available on microcomputers. More structured than BASIC, many experienced microcomputer programmers are turning to PASCAL.
Peripheral	A device which is connected to a computer to enhance its I/O capabilities.
Pilot	An authoring language designed for educational applications which is available on many microcomputers.
PLATO	A computer-aided instructional curriculum developed at the University of Illinois and distributed commercially by the Control Data Corporation.
Port	The place where connectors for peripherals are plugged into a computer.
Printer	A peripheral which creates hard copy. Most printers use either heat (thermal) or form letters, numbers, punctuation marks, etc.
Program	A listing of sequenced instructions which cause a computer to perform specific operations.
RAM	Random Access Memory - The circuits which allow information to be stored and retrieved by the user. In microcomputers, RAM is volatile and is therefore erased whenever power is shut off.

ROM	Read Only Memory - The circuits which store information needed by the computer to operate. ROM is not accessible by the user and does not erase when the power goes off. If a microcomputer comes ready to be programmed, the language commands (usually for BASIC) are stored in ROM.
Save	To store a program for later use. Since RAM is volatile, saving is usually accomplished by recording the program on a disk or cassette.
Scroll	To move text displayed on a CRT to make room for more text. Scrolling usually refers to up-and-down movement but can be used to describe side-to-side movement as well.
Software	A program or collection of programs which cause the computer to carry out specific functions.
TRS-80	A popular microcomputer produced and distributed by Radio Shack (Tandy Corporation) which uses a Zilog Z-80 chip.
Terminal	A peripheral which allows a user to type in information on a keyboard and display it on a CRT or a printer.
Texas Instruments	A company famous for calculators, which also manufacture microcomputers.
Text	Information which consists of words rather than numbers.
Time Sharing	A situation in which more than one user can interact with a computer at any given time.
User's Group	A collection of people who meet to discuss and share informtion about computers.
Vendor	A company which sells computer hardware, software and/or related services.
Word Processing	A program or collection of programs which permit the storage and editing of text.

APPENDIX B

ADDRESS AND CONTACTS OF PROJECTS

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APPENDIX C

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